National Defense Center for Energy and Environment

Designing and Evaluation Zero Energy Housing for Military Installations

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Office of the Assistant Secretary of the Army (Installations and Environment)

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Partners and Performers

Concurrent Technologies Corporation

Project Overview

- Use integrated design and energy modeling to demonstrate zero energy housing
- Validate the potential to provide cost effective zero energy housing
- Transfer project knowledge DoD-wide and beyond

Project Phase

- Design – completed fall 2009
- Construction – began January 2010
- Monitoring – design complete, installation expected in Summer 2010
- Analysis – 12 month monitoring period
- Technology Transfer – in process throughout project

Design Approach and Methods

- Held design team teleconferences to:
  - identify constraints/baseline conditions
  - set performance goals
  - identify specific technologies, tools, and strategies.
- Held two-day design charrette with multi-disciple, multi-organizational team
- Tools used:
  - Integrated Design: Replaces the traditional sequential design process by integrating multiple disciplines early in the process to help identify and optimize systems and reduce overall costs
  - Energy modeling and analysis
  - Life-cycle cost analysis

Constraints

- Street exterior to be unaltered
- Baseline and ZEH to be placed in existing development plan
- Occupants historically not responsible for utilities
- Work within existing floor plan

Baseline Design

- Duplex
- Four-bedroom
- Two-story dwelling
- 1,985 square feet of conditioned space per unit
- 2.5 baths
- Energy Star Rating

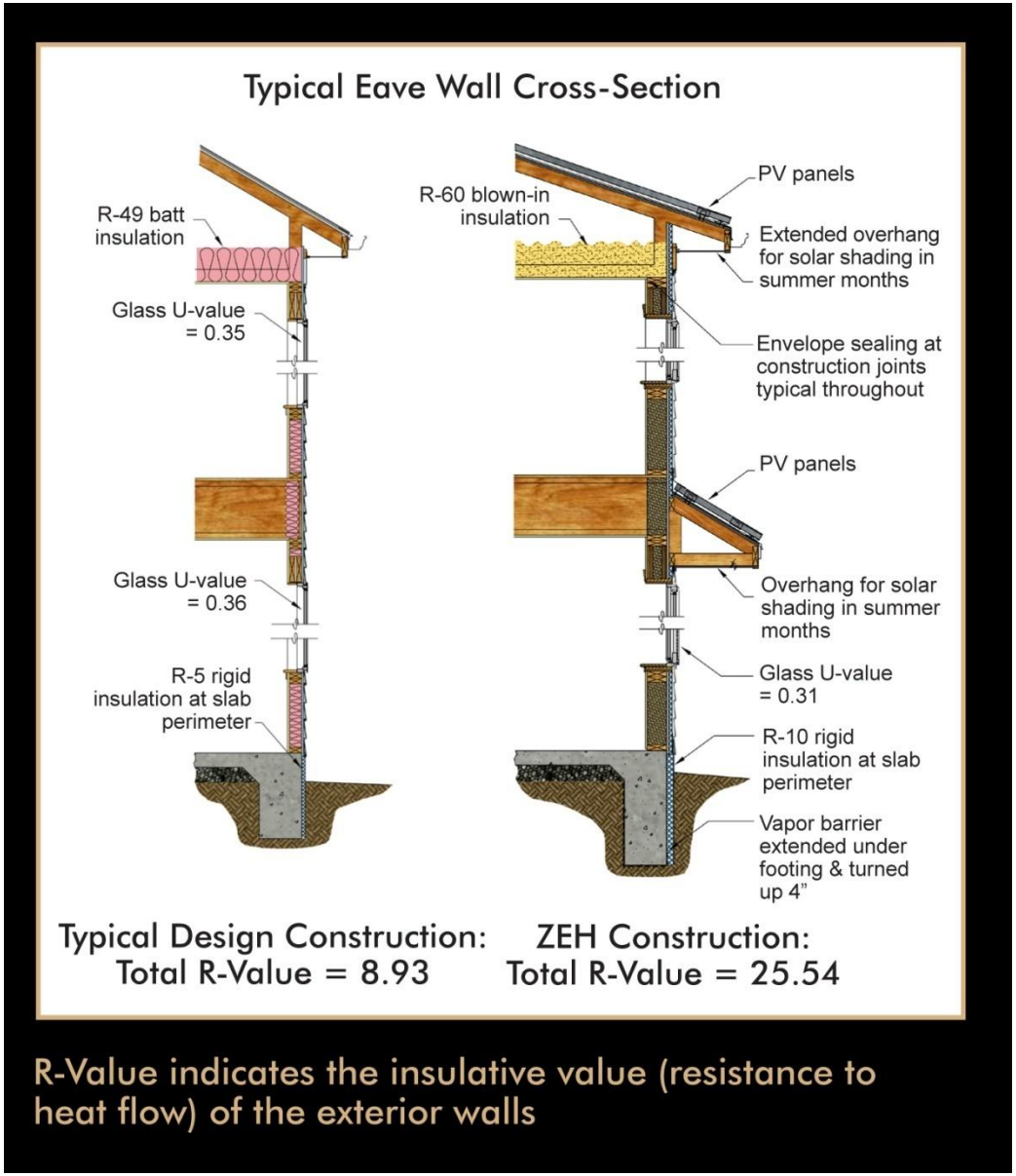
Photo courtesy of Luckett & Farley; Architect of Record.

ZEH Strategies

- Reduce heat transfer through the envelope
- Reduce solar heat gain
- Reduce demand
- Reduce consumption/miscellaneous loads
- Provide on-site renewable energy source

Reduce heat transfer through the envelope

Reduce solar heat gain



Reduce Systems Demand

Increase efficiency of HVAC

GSHP with De-superheater

High SEER air-to-air system

Ductwork sealed and in conditioned space

Solar water pre-heat system

Flat Plate solar thermal water heating

120 Gallon high R value storage tank

On demand hot water backup

Central location for storage tank

All hot water plumbing insulated

Water distribution manifold plumbing

Energy efficient lighting/appliances

Internal CFL's

External CFL's

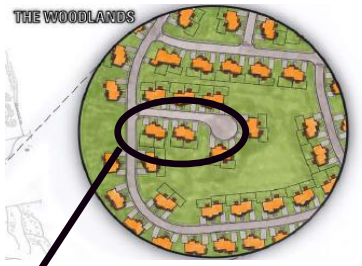
Energy Efficient Appliances

Reduce Consumption/Miscellaneous Loads

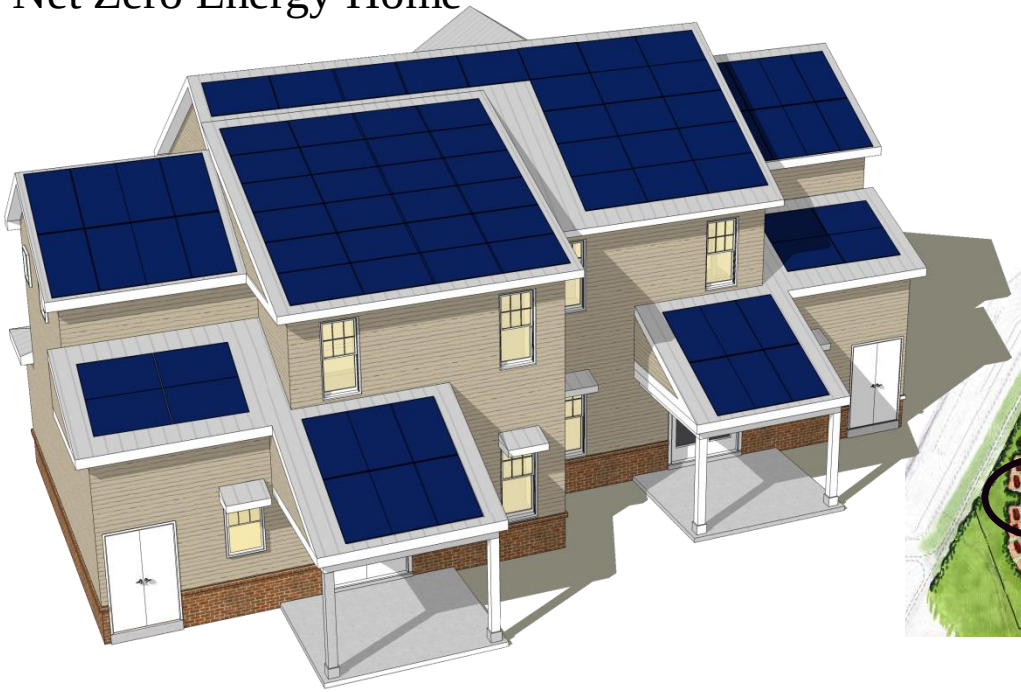
- Resident behavior / habits
- Timers on bath fans
- Control power strips
- Ability to view real-time usage

Optimize Solar Power

Baseline Home



Net Zero Energy Home



On-site Renewable Energy System

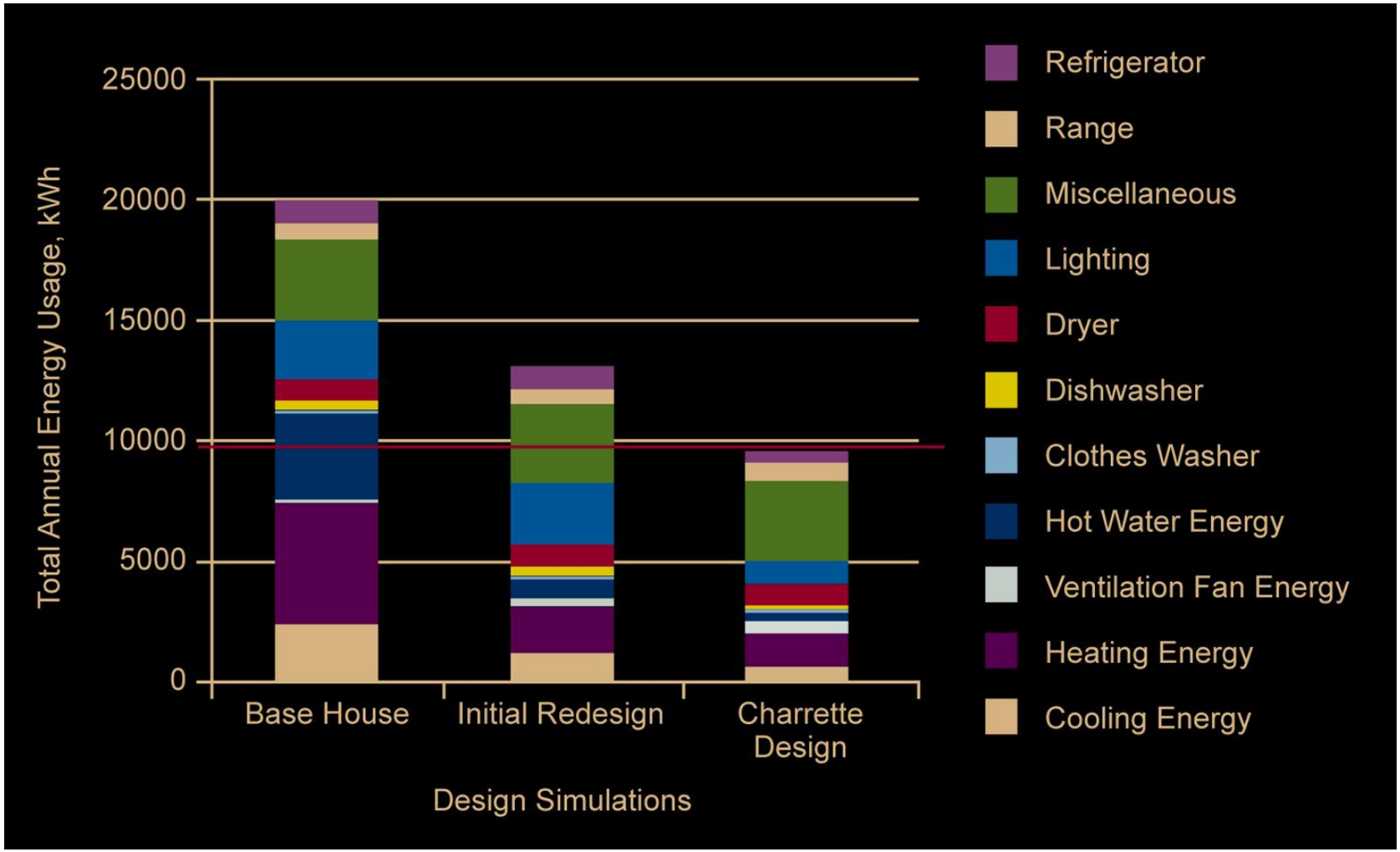
Photovoltaic Modules

- 6 Strings of 11 panels in series 33 – 225 W panels per unit
- 7,425 W per unit

Solar Production

- Clarksville, TN - 4.5 Sun Hours
- Production 9,447 kWh annually

Design Progression - Modeling Results




Construction Progress Photos
Fort Campbell ZEH - January 2010


Construction Progress Photos
Fort Campbell ZEH - February 2010


Construction Progress Photos
Fort Campbell ZEH - March 2010

Construction Progress Photos
Fort Campbell ZEH - March 2010

Construction Progress Photos
Fort Campbell ZEH - March 2010

Construction Progress Photos
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Whole Building Performance Measurement

- Comparing typically designed duplexes with net zero energy duplexes
  - Matched Pairs analysis
- Comparing ZEH with average performance of Ft. Campbell residences
- Comparing ZEH with National Standards
  - Residential Energy Consumption Survey (RECS)
  - Center for the Built Environment (CBE) occupant satisfaction survey

ZEH Performance Objectives

- 14 different Performance Objectives addressing design and performance measurement
- Design Objectives include:
  - Reduce *modeled* energy use
  - On-site energy generation is equal to or greater than modeled energy use
  - Reduce *modeled* potable water demand
- Performance Measurement Objectives include:
  - Reduce *measured* energy use
  - On-site energy generation is equal to or greater than *measured* energy use
  - Reduce end-use energy use

Monitoring Equipment in the ZEH design

- Monitoring needs included in design specifications
- Metering points include:
  - Electricity meters
  - End use meters
  - Water meters
  - Indoor and outdoor temperature and humidity
  - Solar hot water
  - Photovoltaic panels
- In-home, user-friendly displays being selected

Example of monitoring equipment in the ZEH design specification

- **Veris Industries E30 Branch Circuit Power Monitoring (BCPM) device**
  - Installed in the home electrical panel
  - Capable of monitoring 42 circuits
  - Connects directly to data acquisition device via MODBUS (RS-485) cables (provided by electrical contractor)
  - Monitors all sub-level electricity loads

Identify and Train Occupants

- **Occupant Identification Criteria**
  - Willingness to participate
  - Number and age of family members
  - Expected typical occupancy hours
  - Monthly energy use for past year for each family
  - Electronic equipment typically used by each family

Identify and Train Occupants

- **Occupant Training Strategy**
  - Develop and distribute occupant recruitment pamphlet
  - Discuss study goals and occupant expectations with potential occupants
  - Walk-through home with occupants to offer training on how to minimize energy use in the ZEH
  - Provide home operations guide
  - Communicate regularly (monthly) with occupants regarding energy use

Ongoing Interaction with Occupants

- Monthly:
  - Provide written feedback on energy and water
  - Discuss over the phone
- Six months:
  - Meet in person and discuss usage patterns in depth
  - Provide refresher training as needed

- **GOAL: to help both the occupants and the research team understand energy use patterns**

Next Steps

- Complete monitoring
- Summarize and report results
- Present results at energy and construction industry conferences
- Produce case study
- Develop ESTCP reports
- Incorporate lessons learned into over 40,000 military housing units that Actus Lend Lease is building nationwide

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